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THE DEVELOPMENT OF METEOROLOGICAL SCIENCE*

By J. Patterson

WHEN I glance over the long list of presidents that have guided the affairs of the Institute since its establishment in 1849, I appreciate very much the kindness of the Institute in electing me to this high and important office, and the honour that you have conferred upon me by so doing. At the same time I realize the heavy responsibilities that have been placed on the president for the past few years, which duties I hope I may be able to discharge satisfactorily, with the very able assistance of our Honorary Secretary and Assistant Secretary, who are relieving me of a very considerable part of the work.

We have all read with very much interest of the magnificent gift of a 74-inch telescope that Mrs. Dunlap, one of our Council members, is giving to the University, and it is a matter of sincere congratulation to the University, Mrs. Dunlap, and Professor Chant who has worked so untiringly towards this object, that the project has been so successfully launched, by the laying of the cornerstone of the buildings on the 10th of September.

I also feel that I should make a brief reference to the great international project that is being carried out this year by the International Meteorological Organization. This project is known as the International Polar Year for 1932-33. It is in commemoration of the first International Polar Year held fifty years ago. In the first undertaking the British and Canadians jointly occupied

*Presidential Address delivered before the Royal Canadian Institute on November 5, 1932.

Fort Rae, north of Great Slave lake, and this year the British have remanned this station, while Canada has been given the task of connecting the stations in Greenland on the east with Fairbanks, Alaska, on the west, by a series of stations along the arctic circle. We have sent out in all four different parties, the main being at Chesterfield inlet, which is the nearest station to the north magnetic pole, consequently the most difficult of all the stations that will be in operation, and at the same time one of the most important, on account of its proximity to the pole. At this station we have a band of young enthusiastic University men, Mr. F. T. Davies (McGill), Professor B. W. Currie (Saskatchewan), S. McVeigh (Queen's), and John Rae as assistant observer, who have gone forth equipped with all the apparatus it was possible to use, some of it being obtained on loan from the University of Toronto, the U.S. Weather Bureau, the Department of Terrestrial Magnetism of the Carnegie Institution, and the International Polar Year Commission, and several departments of the Dominion Government. Reports from them indicate that their programmes are in full operation, and while it is too early yet to speak of the scientific results, we feel they will be very great.

Mr. R. C. Jacobsen from our own University is carrying out a very extensive meteorological programme at Coppermine. This is our principal meteorological station, and is one of very great importance in studying the influx of the polar currents or polar air into more temperate latitudes.

At Cape Hope's Advance we have Mr. Lilly from Acadia University and Princeton, who is carrying out a full meteorological and auroral programme.

These stations are tied up with our permanent station at Meanook where Mr. Vestine, of the University of Alberta, is carrying on the magnetic work, with a full set of magnetic instruments in use for this occasion.

Some 27 nations are participating in this great undertaking, and it is hoped that the scientific results from their endeavour will more than justify the faith of those responsible for its organization.

Before turning to my lecture proper, I wish to define what we mean by the barometer, barometric pressure, or pressure. It is a

term that is so much used in meteorological work, and one that I shall have to use constantly throughout my address, that it is perhaps well to give you the significance of the term before I begin my lecture proper. We are all familiar, of course, with the pressure in steam engines, pressure in the watermains, in automobile tires, etc., but we use pressure in perhaps a somewhat different sense in meteorology. A good experiment to illustrate it is to take a glass tube with a piston in the bottom, this piston being free to move without any friction, and yet at the same time being watertight. If then water is poured into this tube to the depth of say two feet, what would be the pressure one would have to exert against this piston to prevent it from moving downward? Obviously it would be equal to the weight of water that is poured into the tube. Now, pressure in the atmosphere refers to exactly the same thing. It is the weight of a column of air extending from the place of observation right to the top of the atmosphere and having a unit cross section. It is true this is represented as a height or a length, but the pressure or the barometer is in reality the weight of a unit cross section of air over the place of observation, or what is the same thing, the mass of air over the observing station.

With this explanation, therefore, I shall now attempt to trace the development of meteorological thought and of weather forecasting, and at the same time give you some idea of the varied functions of a Meteorological Service.

Man has always been interested in the weather, and it is not surprising that from the earliest times he has tried to foretell what the weather would likely be. In course of time a great mass of superstitions and legends in connection with the weather grew up, and it was not until the discovery of the barometer in the 17th century, that meteorological thought began to take its place in scientific literature. Even at that time it was discovered that the barometer sometimes read high and sometimes low, and that with a low barometer there was usually stormy weather, and with a high barometer fine weather. Weather forecasting was attempted by the reading of the weather glass, as it was called, and all the signs that we have on our dial barometers, etc., as stormy, very stormy, rain, change, fine, very dry, were all the 18th century predictions, and

have been continued ever since. Very little progress, however, was made in meteorological work until about the middle of the last century, when the introduction of the telegraph made it possible to receive observations quickly and chart them on maps.

Fig. 1 gives an interesting example of the type of weather map that was first prepared. No attempt was made at forecasting, only the weather conditions by means of symbols being printed on the map. The one shown here was drawn in 1863. By 1868 they had added the lines of equal pressure or isobars, and Dr. Buchan had worked out the tracks of some Atlantic storms, which indicated that they travelled. This discovery created very great enthusiasm for the study of meteorology and the production of weather maps. Governments the world over were then being called upon to establish weather services primarily for the benefit of shipping. It was only in 1872, or sixty years ago, that the service was being organized on this continent, and to realize how brief is the period since the real beginning of meteorological science, it is only necessary to recall that it was at this time my distinguished predecessor in office, and a Past President of this Institute, Sir Frederic Stupart, joined the service. Forecasting services, however, were not established without encountering the violent prejudices of the scientific men of the time, and even the Royal Society of London forbade the publication of forecasts for many years, as they considered that one who would give a weather forecast was no better than a charlatan or astrologist, one famous scientist even going so far as to say that no reputable scientific man would ever put his name to a weather forecast. Fortunately for the science there were those who believed in its possibilities, and the great service that could be rendered to the commercial life of the country; time has more than amply justified their faith. The meteorologist has come into his own, and one poetically inclined sets forth its importance thus:

> What is it moulds the life of man?
> The weather;
> What is it makes some black and others tan?
> The weather;
> What makes the Zulus live in trees,
> The Congo natives dress in leaves,
> While others go in furs and freeze?
> The weather.

Fig. 1. Reproductions on a reduced scale of a specimen weather-map of the British Isles issued with the prospectus of the Daily Weather Map Co. about 1863.—From Shaw's *Manual of Meteorology*, Vol. I.

It has always interested me very much at these lectures to hear with what joy the geologist tells about his great discoveries as to the age of the earth, going back to hundreds of millions of years; then there are the physicists; how they enjoy telling us of the very small particles with which they deal, particles so small that as one of our lecturers told us, if Nero threw a pitcher of water into the Tiber, it would by this time have been thoroughly mixed throughout the world, and if so, each of us this evening, in drinking a glass of water, swallowed several thousand particles of that pitcher of water, and yet within these small particles they tell us a whole miniature solar system is in operation. The astronomers excite our admiration when they inform us of the great depths to which they can penetrate the universe; how that light travelling 185,000 miles a second for one hundred million years, is only now reaching us from some of the distant stars.

All this surely makes the meteorologist envious, and he wonders if he has to deal in any way with quantities of these magnitudes, and just to try that out I made quite a simple calculation to see how much air would pass through a cross section of a square mile, a mile along the surface and a mile high, for a wind of twenty miles an hour flowing at right angles to it. It would be well if you could all make a mental calculation of what this quantity is likely to be. It happens to work out to one hundred million tons per hour, and if the energy contained in it could all be converted into power, it would be the equivalent of a million horsepower engine. A mile is a very small distance on the face of the earth. Again, I have noted how we pride ourselves on our great transportation system, how in the course of a single season the two great transportation companies move the great wheat crops of the west, amounting to four or five hundred million bushels of wheat in the course of a single season, and I again make a calculation to see how much nature had to do to provide the rain necessary for the growth of this crop. Nature had to evaporate the water, raise it to the level of the clouds, transport it for thousands of miles and deposit it as rain; in this operation she moved no less than twelve to fifteen thousand million tons of water, during only the growing season, or during the year something like thirty to forty thousand million tons, on the assumption that the wheat averaged twenty bushels to the acre.

Have we not in the atmosphere the world's greatest transportation system, in which all other transportation systems dwindle into insignificance? In all great transportation systems some motive power or engine is necessary, and in examining the situation we find that our atmosphere is wonderfully like an immense steam engine in which the sun is the source of heat; the tropical regions, the boiler where the water is evaporated; the poles, the high mountains; and the tropopause, the cold region or condenser that furnishes the means whereby the water vapour is recondensed into rain or water; and in the light of that, the problem for the meteorologist is to find out the workings of this great atmospheric engine and transportation system. What are the physical processes that are going on in the atmosphere to produce the weather as we have it? Knowing these physical processes we should then be in a position to more accurately forecast what is likely to happen.

When regular weather services were established some sixty years ago they obtained from as many stations as possible, the information that is usually telegraphed, — pressure, temperature, rainfall, wind, cloud, weather,—but at that time the stations were very few on this continent from which observations could be obtained. One of the problems since that time has been the extension of the area to the utmost limits from which observations could be obtained by means of the telegraph, telephone, and radio. Our observations now extend from ships on the Atlantic to ships on the Pacific, from Mexico to the arctic regions. So efficient have the great telegraph systems of this continent become that within forty minutes to one hour from the time the observations have been taken, over this vast region, they have all been received and charted on our weather maps at the central office here, in Washington, and in other forecast centres in Canada and the United States. On these maps two great outstanding systems are prominent. These are shown diagrammatically in Fig. 2; on the right the pressure is low at the centre and increasing outward, indicating that in the centre by some method or other the air has been pumped out from the place of observation. This air must be drawn off from the top and in the process the air is cooled, condensing the moisture which falls as rain. On the left the pressure is high in the centre and decreasing out-

ward. In that region the air by some process or other has been piled up and is settling down and flowing out from the base. These are the two prominent systems on our weather maps. It was only natural that when the main features of this pressure distribution

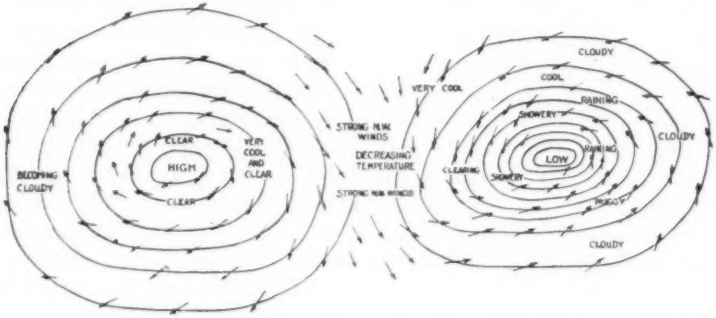

Fig. 2. Diagrammatic representation of pressure distribution, with the associated weather.

was obtained that meteorologists should consider this circulation was continuous about the highs and lows without any discontinuities. I will return to this later.

Fig. 3 shows one of our regular weather maps as they are produced. Here we see the two systems, the high pressure and the low, with the weather associated with them, and with all gradations in between. Now these systems, as already stated, move, and Fig. 4 shows how the map has changed in the space of twenty-four hours. It is from a long study of these maps, which show the distribution of pressure, temperature, rainfall, wind, cloud, weather, etc., of how these systems move, and how they develop or dissipate, that the forecaster is enabled to forecast for the next twenty-four to thirty-six hours, with marked success. The systems usually change so much by the end of the period that an accurate forecast beyond this period is not possible. If, however, they develop differently to what he anticipated then naturally the forecasts are in error to that extent. This method, however, does not necessarily take into account the physical processes that are in operation to produce the weather at the time. It is possibly because of this fact

that physicists trained in physical laboratories have not taken kindly to weather forecasting, because they could not see that they were making any use of their scientific knowledge. Fortunately, however, there were those who had longer vision and considered that one of the functions of a meteorological service is to find out what these physical processes are, in order to understand why the weather

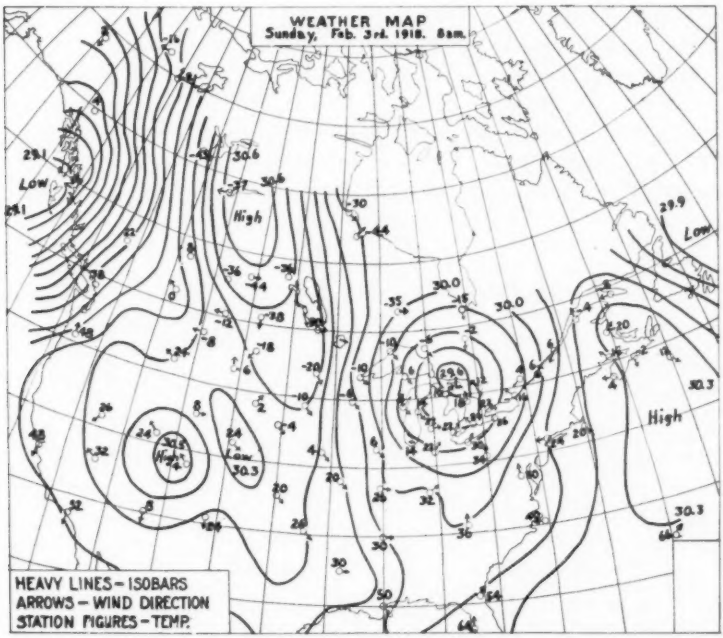

Fig. 3. Weather map showing pressure systems.

behaves as it does. The first step in solving this problem must be to know the facts, and the only way to get them is by observation or experiment. Unfortunately we cannot go to the physical laboratory for such experimentation on the vast scale on which the atmosphere operates. Our weather comes and it goes. We take what observations we can, and wait until the same conditions repeat themselves, or approximate to them.

The observations that are charted on the weather map are all taken at the surface of the earth, except the cloud, that is, our observations are taken at the base (a very irregular one) of the atmosphere in which we live. To attempt to solve our problem we must know what is going on throughout the atmosphere in regions where the weather processes are in operation, the surface observa-

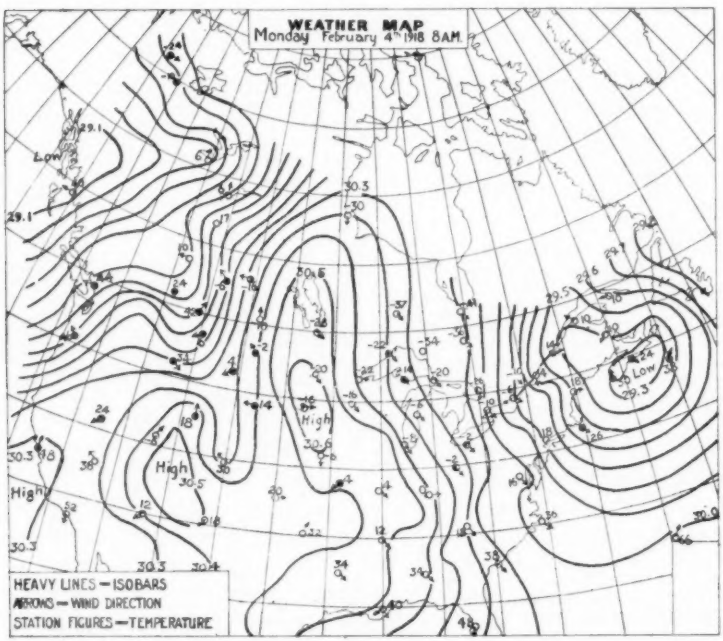

Fig. 4. Weather map similar to the previous one, but 24 hours later.

tions being in reality only a reflex action of what is happening throughout the atmosphere. This has involved a long investigation, carried out by means of kites, balloons carrying instruments, manned balloons and now aeroplanes. So far it has given us a new conception of the weather processes, but it is not my intention to dwell on this, as it would take far too long; sufficient to say that from the work of Sir Napier Shaw and the Bjerknes, father and son, we now

believe there are two great currents operating at least in the temperate latitudes that determine the character of our weather. These currents are known as the equatorial and the polar. As the name implies, the equatorial is very warm and generally moisture laden. On the other hand, the polar current is cold, and being from polar regions, it is very dry. These currents thus have very markedly different characteristics and very different properties. They have also the remarkable property that they can exist side by side for great distances without appreciable mixing, and it is along the line of separation of these two currents or the lines of discontinuity that all our storms and bad weather occur.

Fig. 5 illustrates the ideal conditions. Here we have the warm air from the south cutting into the cold air from the north, and we often speak figuratively about the war of the elements. There is

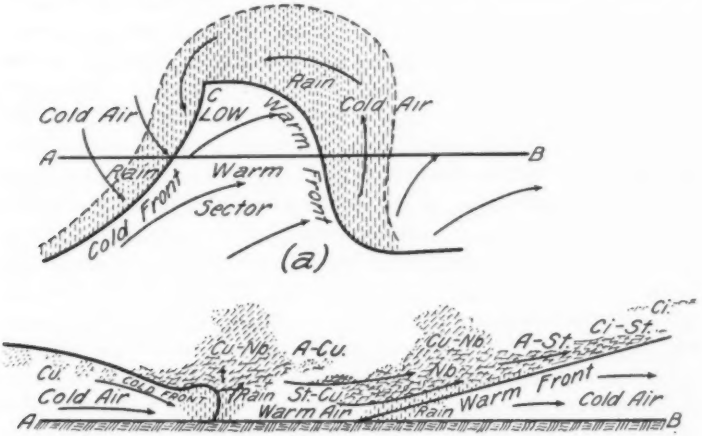

Fig. 5. Horizontal and vertical sections of an "idealized cyclone". (Blocks for Figs. 5, 6, 7 were kindly loaned by *The School*, Toronto.)

perhaps more truth in that than we ever realized, for are not these two great currents very much like two immense armies, one the army of the south, the other the army of the north; the southern army represented by the equatorial current impinges along the warm front and drives back the cold air, at the same time the warm air flows up over the top of the cold air, as shown in the lower part

of the diagram. As this warm air rises higher and higher we get first of all the low heavy cloud and rain, then further out the alto stratus or alto cumulus, then still further the thin wispy cloud, the cirrus, the forerunner or vanguard of the approaching storm. In the region of the warm front, the sky is overcast and the rain generally falls as drizzle, or steady rain, while if conditions are very unstable thunderstorms are probable. If we take a section through the northern part, we see that these conditions extend right through the storm area. Along a southern cross section as AB, Fig. 5, we pass from the region of cloud and rain into the region of the equatorial current where the sky is generally comparatively clear, with the temperature higher than usual, and it may also be hot, oppressive or muggy. This explains how after the first rains have passed we frequently come into another region where if anything the weather is more oppressively hot than it was before the rain.

While our southern army, as it were, has been driving back the army on the north, the latter has not been idle. It sweeps around to the flank and undercuts the equatorial current along the cold front. Here we have the ideal conditions for a battle of the giants. The cold air suddenly undercutting the warm moist air forces it up and produces a terrific commotion all along the front. The approach of this cold front is frequently heralded by the developing thunderstorm in the distance, a sure forerunner of an approaching storm, or there may be the long roll cloud indicating the line squall, so called because at times it may be perfectly straight for hundreds of miles, all indicating terrific commotion in the air. In the narrow band along this front the air is forced up to immense heights, and accompanying the passage of the front we have the line squalls, the thunderstorm, hail, etc.

When we pass from this region into the rear the clouds thin out rapidly and as the cold air sweeps on we come into the dry clear air from the polar regions. In the winter these are the great cold waves. They, of course, while passing over the continent gradually warm up, take up moisture, and eventually as they pass out they have lost much of the characteristics of the polar air.

Returning now to Fig. 5, the cold air in cutting the flank of the warm air, may at times go right clean through the equatorial current

and then we have the warm equatorial air, the southern army, as it were, cut off from its base of supply, thus causing the death of the storm. The equatorial current, however, reforms, may I say, and again attacks the cold air to the north, thereby producing a secondary and the process is repeated.

This is, in brief, the process that is going on in the atmosphere in the production of our weather. We understand more fully the processes that determine whether the seasons are cold, wet, dry, etc.; the season depends very largely on which current predominates, and the activity of each. At times the equatorial current may penetrate very very far to the north, the weather in consequence is likely to be warm or hot, with very little rain, or again the cold air currents may penetrate far down into the continent and we have the cold winters, or if sometimes one and then the other prevails, a season with plenty of precipitation.

This investigation then has thrown new light on weather forecasting, thanks to the energy of Bjerknes. It offers now a scientific explanation of the weather processes, and as such is appealing to scientific men to investigate and to study. It is a most fascinating subject and one that opens up vast possibilities for the future. The conditions that I have sketched are, of course, ideal, and as in all cases, there are very great variations from these conditions.

That this ideal cyclone is true to actual conditions is shown by Fig. 6, a weather map for August 31st, 1932, the day of the total eclipse in Quebec. As you know, the eclipse was seen only by a few, and then when the clouds happened to break at the time of totality. Here you see the great invasion of warm equatorial air flowing up against the old continental or retreating polar air. This warm air rising up over the colder air produced cloud and in some places rain, which marred the day. If you examine these conditions you see that on the warm side of the line the temperature is much higher than on the other. You see also that there is a change in wind direction. This indicates that a discontinuity exists along the line that separates the equatorial from the old continental air. Passing through this section we have this warm polar current flowing over most of Ontario and during that day you will remember the skies were generally clear. Back further still we see the invasion

of the polar air all along the cold front, with very marked difference in temperature, across the line, differences amounting to 10, 12 or more degrees. The winds on the eastern side are southerly, indicating the equatorial current. On the other side they are from a northwesterly direction, indicating cold polar air. At that instant rain has been falling along the area that is hatched. Thunderstorms occurred in certain districts, and at one of the stations a wind of

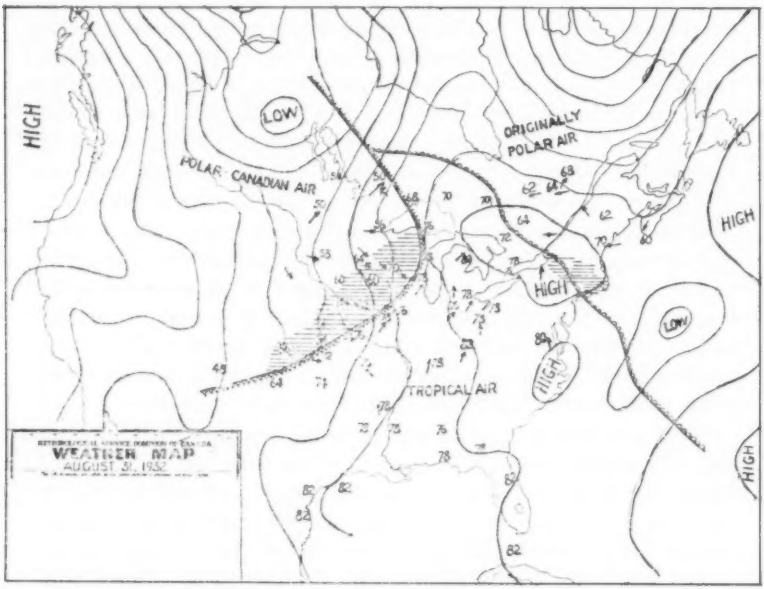

Fig. 6. Weather map for August 31, 1932, 8 a.m.

60 miles an hour was reported. This is the line of squalls, thunderstorms, and generally heavy showers, although, of course, as previously stated, there are all sorts of gradations in the weather conditions, and the great problem is to interpret these conditions. Note the marked lines of discontinuity as opposed to the earlier views. Fig. 7 shows the position of these currents 24 hours later.

In Europe, where these methods are almost entirely used in forecasting, they have to deal with a different type of front to what

we have. When the storms arrive in Europe they are almost all occluded depressions; the cold air has cut through and they are in a dying condition. On the other hand, we are in the region where these low pressure systems, depressions or fronts, are developing and consequently we have a very much more difficult problem to unravel. I am very glad to say, however, that this is being investigated, and while it will take a very long time to work out, yet it is

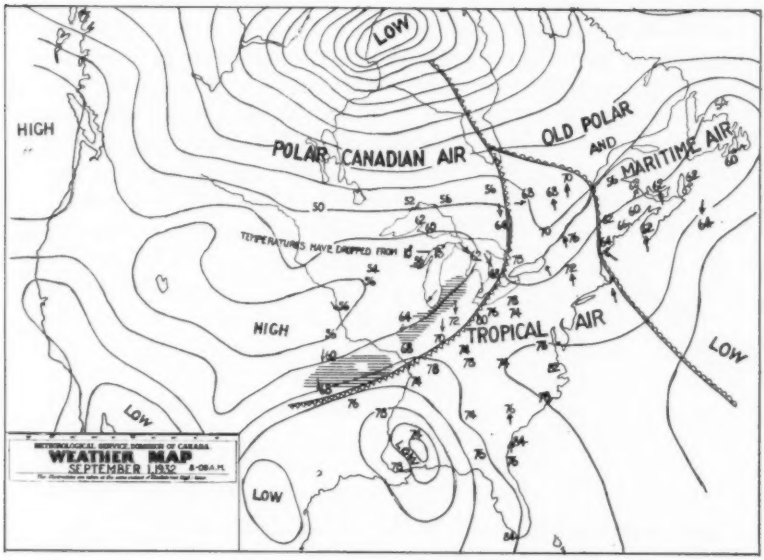

Fig. 7. Weather map for September 1, 1932, 8 a.m.

a subject of fascinating interest. It is only by a long study and knowledge of how these systems usually behave that successful forecasting can be carried out. It is the natural development that is taking place in meteorological thought.

This, however, is not the only means by which the meteorologists are attacking the forecasting problem, and Sir Napier Shaw has attempted another method on entirely different lines. He is endeavouring to get back to fundamental principals and to obtain the energy in the atmosphere, and in that way forecast what is

likely to happen. This involves a knowledge of the structure of the atmosphere to great heights, and is illustrated best in Fig. 8. The diagram shows the amount of available energy for a kilogram (2.2 lbs.) of air, as it ascends into the atmosphere. The upper one represents conditions on the 5th of July, 1911, about the end of that exceedingly hot spell when the highest temperatures ever

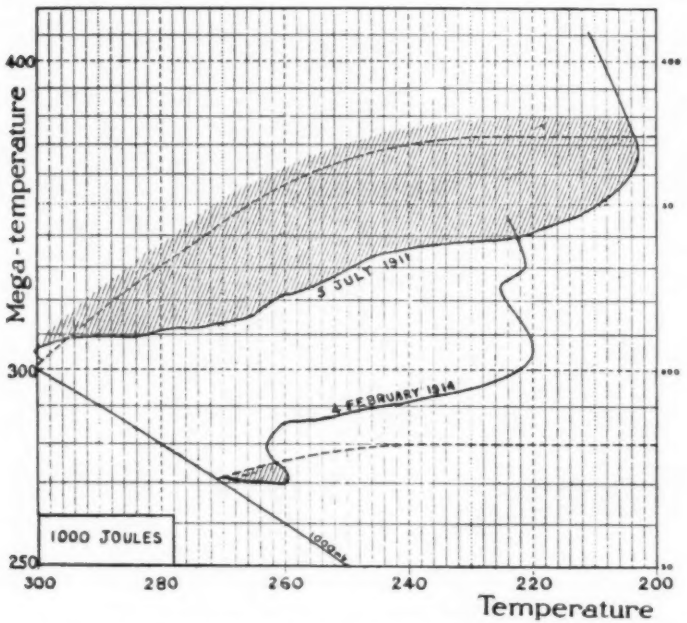

Fig. 8. Soundings by balloon at Woodstock, Ont., on July 5, 1911, and February 4, 1914, referred to temperature and entropy as co-ordinates.—From *Proceedings of the International Mathematical Congress*, Toronto, 1924.

recorded in Toronto occurred. This ascent was made at Woodstock, and without troubling you about how this diagram was obtained, the stippled area shows the amount of energy in a kilogram of air available for weather processes at that time. A kilogram, however, is a very small unit for meteorological purposes, in fact it is an atomic unit. If instead of this kilogram we could consider saturated

air a mile high and drawn from 100 square miles of surface, the energy available in that unit would be 160,000,000,000 horsepower hours, truly a tremendous amount of energy.

On the other hand, the lower diagram which represents an ascent in February, 1914, shows an entirely different condition; the heavy line indicates the actual conditions existing, and the light line, the line of stability, if I may so call it. This line of stability is well below the actual conditions. On the other hand, the upper one shows that the line of stability is very much higher than actual conditions. In the lower example, the air is exceedingly stable and it would be an utter impossibility to get any rain or snow out of it. On the other hand, the upper one represents very unstable conditions, with an immense amount of energy for the productions of rain; at that time violent thunderstorms were occurring in the neighbourhood.

If now these diagrams could be prepared for a sufficient number of places we would then know how much energy there was in the atmosphere for the weather processes, and from that we could make an accurate estimate of what conditions were likely to be. These diagrams are being prepared at the airports, and it is possible with the extension of aviation and increased facilities for obtaining the conditions high up in the atmosphere that this method will take a very important place in meteorological services.

There is thus a very great attack being made on the problem of the weather, in order to improve forecasting, so that the Meteorological Service may be of greater and greater benefit to the industrial and commercial life of the community. I look on the Meteorological Service as a great insurance agency, an agency that can render great assistance to those engaged in the various pursuits of life, and I shall now take up briefly some of the aids that we are rendering.

As stated at the beginning of my address, meteorological services were organized primarily for the warning of the approach of violent and dangerous storms and gales, and this is one of its great functions. It is of the utmost value for all small coasting and fishing vessels and small craft that ply along our coasts that they should know beforehand of the approach of bad weather. For this purpose we have issued warnings telling the mariners of the

approach of storms that are likely to cause gales, by a system of signals, and now by radio also.

Storm warnings are issued for the maritime coasts on the Atlantic and on the Pacific, and also on the great lakes, during the seasons of navigation. It is true that the storms are not violent as a rule for boats that ply the great lakes, until the latter part of the year when storms come up quickly and may become very intense. The importance of being able to warn the shipping of the intensity of the storms and the probable weather in connection therewith, means a very great deal to the safety of the ships on the lakes. It is a subject that is receiving much attention, and one that I hope we may be able to extend and to develop when more propitious times return. With the aid of wireless it should now be much better what the conditions on the lakes are like, rather than having to judge of them from the comparative shelter of the land.

The Meteorological Service has also been called on at times to advise those who are towing logs across open water of the weather possible to get reports from ships on the lakes, and thus realize conditions suitable for this operation. One of these tows may contain over a million feet of lumber and if caught on the open lake in only a moderate sea it would probably be broken up and most of the logs lost. It is important, therefore, that they should know accurately whether the weather will be propitious for their work, and this is perhaps one of the most difficult operations for which we are at times asked to forecast; at the same time the value of a successful forecast for even a single tow of logs is very great.

Agriculture is vitally interested in the weather. It is on the weather that the success of agricultural operations depends. A knowledge, therefore, of the weather and the climate is one of the essentials in these days of intense competition for the successful pursuit of agriculture.

This involves the measurement of temperature, rainfall, cloud, sunshine, etc., all factors that go to produce the crops that we have in Canada. In the West as you know rain is the great controlling factor and an accurate knowledge of the rainfall that has actually occurred is of inestimable benefit, as it is so easy for false rumours of rainfall or other injurious weather information to get out to the

detriment of all those vitally interested in the crop. This means that we have to have a very extensive weather service throughout the country to collect all the information that we usually associate with climate. For this purpose we have something like 900 stations scattered across the country, but this is a very small number when compared with other countries. An accurate knowledge of the climate enables agriculturists to know what it is possible to do and what is not possible.

Again, it is found by the entomologist and scientific agriculturists that the activities and control of insects, fungi, and all diseases that prey on the crops are governed very largely by the weather, and they are begging of the meteorologist to furnish them with the weather conditions in order that they may know best how to control these outbreaks. The more accurate knowledge they can get of the weather conditions and of the probable course of the weather the more efficiently can they attempt control measures and predict outbreaks. Then there are the control operations such as spraying that orchardists have to resort to in order to keep their crops free from infestation. This spraying cannot be done if the wind is too high; apparently a wind of 14 miles per hour is sufficient to prevent the orchard being properly covered by the spray. Then again, some poisons attack the leaves and injure the foliage if it is put on when the leaves are wet; in which case it must be put on long enough before rain that it will become thoroughly dry, otherwise it burns the foliage. On the other hand, certain sprays can only be used to advantage when the leaves are wet. Some pests only become active in certain weather conditions, and unless spray is put on about that time the work is largely lost. There is thus a very close connection between the weather and the proper care of the orchards, and the Meteorological Service is called upon to give them forecasts in connection with these spraying operations. It is a service that we hope will develop more and more as the part the weather plays becomes better and more thoroughly understood. It is very highly developed in the orchards in the United States, and when we consider the cost of the application of a single spray over a province or state, one can realize the importance of having it put on at a time that will not mean wasted effort and great loss.

Orchards are at times subject to immense damage by heavy gales that pass over them when the fruit is nearly ripe. The fruit growers are hoping that they may be able to insure their crops against damage by wind, but the problem is to know what winds or what types of wind will cause this damage, and what are the chances of these winds occurring. They are looking to the Meteorological Service to supply them with this information.

At certain seasons of the year we have the early frost that ruins the crop and causes tremendous damage. By suitable warnings, and the growers have the means whereby they can protect their fruits or products against the frost, the situation can be saved, and the fruit season very appreciably extended. Perhaps the greatest organization in this respect is that of the frost warning service in California where the citrus fruits are subject to frost at a period when tremendous damage is likely to be done. Being warned of the approach of the frost by the Weather Bureau the orchardists keep oil heaters burning during the period of danger. By this means the temperature of the air is raised sufficiently to prevent freezing. They take advantage of a very interesting phenomenon occurring in nature. These frosts invariably occur when the nights are calm and clear and radiation very strong; the ground and trees are cooled by the radiation passing out to space, resulting in the air near the surface being cooled below the freezing point, whereas just above the height of the trees the temperature is well above the freezing point. Now this heated air from the oil heaters can only rise until its temperature is reduced to the temperature of the air and as the air is getting warmer with height it cannot rise once its temperature is reduced to that of the air, consequently it must flow out under this warm layer, and in that way form a protective layer over the whole of the orchard, the heat gradually extending down to the surface and thereby raising the temperature of that portion of the air above the freezing point. When one, therefore, contemplates the tremendous part that weather plays in all agricultural activities one can realize the great importance of a meteorological service to agriculture.

Foresters are constantly in fear of that most dread monster, the forest fire. These great fires break out at times and sweep through

the forest, wiping out everything in their path. As we all know, they do immense damage to the forests and cause tremendous loss to the country thereby. All forest fires occur during definite weather conditions. This was known in a sort of general way, but until a few years ago it was generally accepted as an act of God, and nothing could be done about it. With, however, the advent of the scientific forester, the problem of the cause of forest fires was attacked in earnest in an attempt to find the real cause of the conditions that are favourable for forest fires, and knowing this to put into practice the various means by which the hazard may be lessened. Investigation shows that all the debris, humus, as dead leaves, dried grass, etc., on the forest floor are hygroscopic, they take moisture out of the air depending on the relative humidity or the degree to which the air is saturated. An excellent illustration of a hygroscopic substance is an oak floor, which dries out and contracts very much during the winter owing to the dryness of the rooms, and expands in the summer when the humidity becomes much higher. These substances then follow to a certain extent the trend of the humidity, that is in the middle of the afternoon the humidity is relatively low on account of the high temperature, then at night when the temperature becomes much lower the relative humidity becomes higher, and to quite an appreciable extent the hazard passes. This is particularly true in regard to the dried grass in the early spring before the new foliage or new cover has had time to develop. The actual debris on the forest dries out with time, partly dependent on humidity. It of course varies also with the forest cover, that is a dense growth of forest or evergreen as against the burnt over or cut over country where there is little protection. It is a very complicated problem, but the departments of forestry in Ottawa, and in all the provinces, the Canadian Forestry Association, etc., are doing their best to educate the public to the dangers of forest fires. The Dominion Department of Forestry is taking a very active part in carrying on investigations in order to find some means by which they can tell when a hazard is approaching. This was also studied by the Quebec Forest Industries Association and by the forest services in the United States. We have been co-operating in the work, as it is to a very great extent a meteorological problem. We are now asked

to forecast the type of weather that is conducive to forest fires and to the production of fire hazards. When these are likely to occur special precautions are taken, settlers are not allowed to burn slash, campers and tourists are forbidden to go into the danger sections, etc. It is another field that is opening up for the Meteorological Service and one in which we can render a very great service to the country in the protection of the forests, one of our most valuable assets.

The last and greatest development that has taken place in meteorological science is in connection with aviation. It is recognized that an efficient weather service is one of the essential features for the successful operation of air routes. It has been said that with the development of aviation, meteorology has come into its own. While it is true that it is temporarily in abeyance in this country, there is no doubt that with the demand for greater and greater speed in the transportation of mails and express, aviation will become one of the great transportation systems in this country. It is so all over Europe and in the United States. There is every reason to believe that in the course of time there will be great airways connecting the continents, and when that time comes Canada will occupy a very unique position because all the great highways of the northern hemisphere pass over Canadian territory. It thus presents to the Meteorological Service a very great problem, and we should be prepared as far as is possible when this time comes.

There are four very distinct phases of meteorological work in connection with aviation. First there is the long distance flying when the aviator wishes to have a forecast for perhaps a day or two, or the duration of his flight; the pilots always want about the same information, chances of fog, low cloud, poor visibility, and the kind of winds, etc. This requires forecasts for the period for which we usually make them, or even longer; then on scheduled air routes where the stops are comparatively frequent, the aviator requires a forecast only for the time he is likely to be in the air. The more accurate this forecast can be the more use the service is to him, and it is in this connection that the latest developments in forecasting are so very essential. The polar front methods are used altogether in Europe, and Figs. 6 and 7 show how it is possible to use these

weather maps for short forecasts. With maps such as these before the forecaster, it is possible to tell with a high degree of accuracy what the weather is likely to be.

The warm front line indicates where fog is likely to close in and develop, consequently should a man with this knowledge before him be caught in the fog, it would enable him to know in which direction he should fly to try to get out of it. There would be no use flying along the warm front, as he would only be running into more and more fog, whereas by striking out at right angles to it, he has a chance of getting free; then we know that if a cold front is approaching he is apt to encounter violent line squalls.

A forecast some hours before a plane leaves as to whether it can get to its destination in time is essential in order that those responsible for the operation of the route may use other means of despatch when the chances are definitely against the plane getting through. The direction and velocity of the upper winds are very essential in order to give pilots their best flying levels. It has been found that the winds vary so much with height that a knowledge of what these are at the various elevations means a very great deal in the economical operation of a route. It not infrequently happens that the surface wind is strong against the pilot, whereas two or three thousand feet higher he may have a following wind. One can see, therefore, that for a plane going in one direction they should fly high, and in the other, fly low. This information is regularly furnished to pilots on all organized mail or express routes.

I have tried to give you some of the main features of the work that the Meteorological Service is undertaking. I have not referred to the daily forecasts that are issued for the benefit of all those who may be interested in them, nor of the many various calls for weather conditions and information in all sorts of pursuits. No mention has been made of the many methods and duties incidental to a weather service in order to provide weather data, find new means of attacking the problems, designing the requisite instruments, etc., all working towards the one great end of making the service of greater benefit to the country.

In this country we are favoured with a very great opportunity to work out the weather processes. We have the great polar regions

to the north where apparently these polar air currents originate, and one of the outstanding results during the International Polar Year will, we hope, be a better understanding of the problems connected with these currents which are being attacked by all the means at the command of the meteorologist.

NOVA OPHIUCHI NO. 3

By J. A. Pearce

THE irregular variable RS Ophiuchi, which for the past thirty-five years has been a star of the eleventh magnitude, has repeated its nova-like outburst of 1898 and is now a seventh magnitude star. As it will certainly fade several magnitudes during the coming months, the observers of our Society are requested to make estimates of its visual magnitude by the Argelander method, and to forward their observations to the writer.

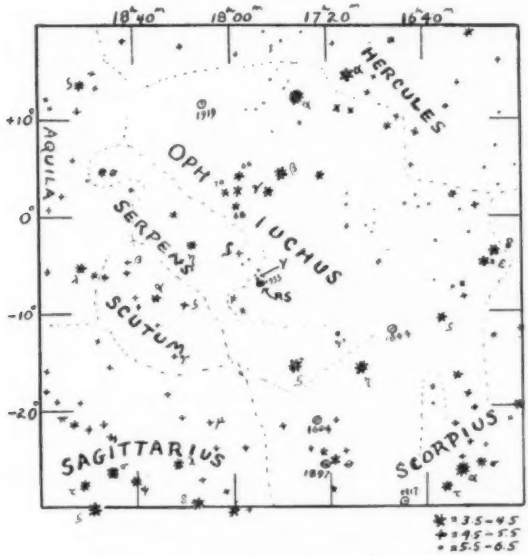

Fig. 1. The New Star, RS Ophiuchi.

The large scale map of the sky (see Figs. 1, 2) should readily enable one to locate the temporary star, with field glasses or a small telescope. The nova is about four degrees south west of the bright star Zeta Serpentis, magnitude 4.60. Between Zeta Serpentis and RS Ophiuchi is a trapezium of sixth magnitude stars. The cepheid variable Y Ophiuchi, magnitude 6.2-7.0, is in the south-

west corner of this trapezium, nearest the nova. The temporary star may be immediately recognized by its very deep red colour, in contrast to Y Ophiuchi, a yellow star of the solar type.

The telegraphic communication from Harvard College Observatory announcing the sudden outburst of RS Ophiuchi was

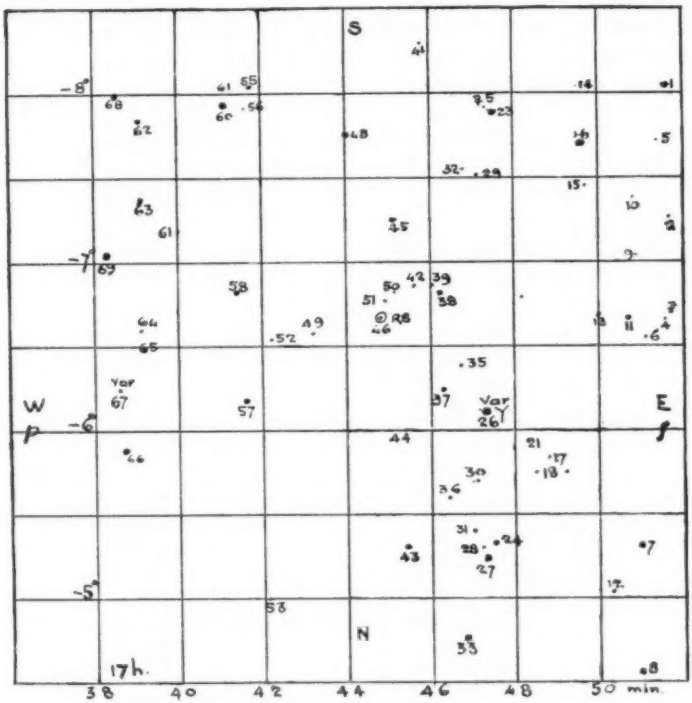

Fig. 2. Region around RS Ophiuchi, R.A. 17h. 44.8m., Decl. —6° 40′ (1900). Plotted from Henry Draper Catalogue by H.B.B.

received on August 16. On that evening the writer examined the star with Mr. H. Boyd Brydon through the 4-in. refractor at his private observatory in Oak Bay, Victoria, B.C. We estimated the nova to be of magnitude 6.8. On August 15, it was observed to be

6.4 by L. C. Peltier, of Delphos, Ohio. According to Dr. Shapley the nova was fainter than 8.0 on August 9, as it was invisible on a plate taken at the Oak Ridge station of the Harvard Observatory. On a plate taken on August 14, it was of magnitude 6.0. Thus the 100-fold increase in brightness must have occurred very suddenly, a well known characteristic of novae.

Mr. Boyd Brydon has prepared the accompanying chart of all stars in the Henry Draper catalogue in the immediate neighbourhood of the nova which will be extremely useful in determining the magnitude of the star as its light fades. The apparent magnitudes and spectral types of the reference stars are tabulated below.

This is the second observed outburst for this star. From 1880 to 1891 its magnitude was 10.9. It brightened to 10.4 in 1894 and retained this brightness with slight variations until 1897. In 1898 it was again observed to be faint, 10.8 on May 31, but on June 30 its magnitude was 7.7. By July 14 its magnitude was 8.2 and it

STARS IN REGION OF RS OPHIUCHI

Map No.	Mag.	Type	Map No.	Mag.	Type	Map No.	Mag.	Type
1	7.8	G0	25	9.0	G5	48	8.2	K0
2	8.9	K2	26	6.2-7.0	G0P	49	9.5	G0
3	9.2	A0	27	6.92	K0	52	9.0	B9
4	9.2	G0	28	9.2	G0	53	9.7	K0
5	9.3	A2	29	10.0	K5	55	8.8	G5
6	9.0	K2	30	9.5	A0	56	10.2	G0
7	8.2	K5	31	8.8	B9	57	8.2	G5
8	7.65	B9	32	9.3	K5	58	8.8	K2
9	10.4	A0	33	8.2	B8	59	10.0	G0
10	9.8	A2	35	9.8	A0	60	7.32	G5
11	8.2	F2	36	9.5	F2	61	9.8	A0
12	9.20	K0	37	8.6	A0	62	8.8	Mb
13	10.4	A3	38	8.4	K5	63	8.2	G5
14	9.8	G0	39	9.8	A0	64	9.5	A0
15	9.0	A0	41	9.3	F5	65	9.8	F8
16	6.87	G5	42	9.2	G0	66	7.32	K0
17	10.0	G5	43	8.4	A3	67	9.6-10.7	Bp
18	9.8	F8	44	10.2	K5	68	8.6	G5
21	6.89	K0	45	8.8	F8	69	6.20	B5
23	7.6	G5	46	var.	Ocp			
24	7.82	K0	47	9.2	A3			

gradually faded at the rate of a magnitude a month becoming 10.8 by October 8. Two spectrograms taken on July 14 and 15, 1898, showed a nova-like spectrum consisting of bright lines on a faint continuous spectrum. The hydrogen lines H β to H ζ were bright, while emission bands were observed at λ 4686 ionized helium, λ 4638 ionized nitrogen and λ 4471 helium, as in novae. Because of its spectrum and its light-curve the star was regarded as a typical nova and designated Nova Ophiuchi No. 3.

The map shows the position of the six temporary stars which have occurred in Ophiuchus. On October 10, 1604, Brunowski observed a star as bright as Jupiter, which continued visible for nearly two years. On the night of April 28, 1848, Hind observed a fifth magnitude star in a region where he was certain no star as bright as the ninth magnitude had previously existed. Its brightness continually decreased from its discovery, undergoing certain remarkable changes. Its colour was described as ruddy, similar to the present colour of RS Ophiuchi. We now know that this is due to the fact that the greater part of its light is concentrated in the deep red hydrogen band Hα. Two novae discovered by Woods in 1897 and 1917 are tabulated by Stratton in his article on novae in *Handbuch der Astrophysik*, although the details of these objects are not known to the writer. Nova Ophiuchi 1919 was discovered by Miss Mackie at Harvard College Observatory. Its magnitude was 9.4 on August 20, but it has not been found on any plate prior to that date. It attained a maximum of 7.5 on September 13, declined to 9.5 in October and then revived to a second maximum comparable to its former one on November 5. By November 13 it faded to magnitude 8.8, and gradually declined beyond the 11th magnitude. Spectroscopic observations were taken by Wright at the Lick Observatory as late as August 11, 1920.

RS Ophiuchi is too far south to be studied satisfactorily at our observatory. Spectroscopic observations were made on August 16 by Dr. C. S. Beals, on the 26th by Dr. F. S. Hogg and on the 17th, 20th and 25th by the writer. A description of the spectrum on these nights will be given in a subsequent note.

Dominion Astrophysical Observatory,
Victoria, B.C., August 30, 1933.

THE AURORAL SPECTRUM AND ITS INTERPRETATION*

By Lars Vegard

THE paper gives a summary of results of investigations carried out in Norway from 1912 up to the present by the writer and collaborators.

Spectrograms from Bossekop 1912-13 showed that the blue and violet part of the auroral spectrum was dominated by the negative nitrogen-bands and that the strong green line had a wave-length considerably greater than assumed at that time.

Measurements carried out at Oslo (1920-21) gave the wave-length of the green line 5577.6 with error less than 7 Å and in good agreement with the nearly simultaneous measurements of Slipher. On the basis of these results Babcock obtained for the green line of the night sky 5577.350.

Spectrographic observations made at Tromsoe (1922-26) gave about 50 lines and bands, most of which were situated in the region 4710 and 3100 Å, where the stronger bands belong to the negative and the second positive group of nitrogen. No hydrogen or helium lines were observed, but a few faint lines were referred to the line-spectrum of nitrogen and perhaps oxygen. Two green lines or bands (5238 and 5139) and red bands referred to the first positive group of nitrogen were observed.

A line near 6300 is remarkable because its enhancement was found to be responsible for the red color of certain aurora. The enhancement of this line appears to be a "universal" phenomenon taking place simultaneously at Oslo and Tromsoe and seems to follow the 11-year sunspot-cycle.

The relative intensity of the most prominent lines and bands within the auroral spectrum was determined and corrected for atmospheric extinction. The auroral spectrum was found to vary with auroral type and with altitude.

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*From *Transactions of the American Geophysical Union*, 1933.

Spectrograms were taken of the negative nitrogen auroral bands with large dispersion for temperature-determinations within the auroral region.

Complete account of the results of observations from 1922 to 1926 will be found in a recent paper by the writer (Geofys. Pub., v. 9, No. 11, 1932).

In 1930 the spectral work was combined at the new Auroral Observatory, Tromsoe, built with funds granted by the Rockefeller Foundation, with L. Harang and later also E. Tönsberg as collaborators.

Special attention was paid to the explanation of the long-wave region of the auroral spectrum. From spectra in the infra-red we have as yet measured seven bands belonging to the first positive group of nitrogen. Infra-red bands were recently obtained with a grating-spectrograph giving fairly large dispersion in that region. The nine bands obtained are not yet measured. A considerable number of lines and bands in red were obtained with spectrographs of considerable dispersion. Most red bands belong to the first positive group of nitrogen. Two lines 6302 and 6367 nearly coincide with the OI-lines ($^1D_2$-$^3P_{1,2}$); but may also be referred to the positive group of N_2 and their origin is still uncertain. Besides the second green line, 5239 and a few other green lines were observed.

In the region of short waves some diffuse bands were observed which coincide with vibrational series typical of solidified nitrogen.

Up to the present 83 lines and bands have been observed, which means that 33 new lines and bands have been detected through the work at the new Auroral Observatory.

The strong green line has been accurately measured with an interferometer. The results, which will be published together with L. Harang, gave values in good agreement with those of Babcock, showing that the green auroral line is identical with that of the night sky. Interferometer-spectrograms corresponding to directions parallel and perpendicular to the ray-streamers were obtained. No Doppler effect was found.

The so-called N_1-line from solid nitrogen as it appears in mixtures with neon was found within the limit of error to coincide with the strong auroral line, and the N_2-, N_3-, N_4-bands of solid nitrogen were found to coincide with other auroral lines or bands.

The accuracy with which the green auroral line fits in with the OI-line ($^1S_0$-$^1D_2$) is, however, most remarkable. But if this interpretation of McLennan is right we should expect to find in the infrared and visible part of the auroral spectrum a number of OI-lines, which, however, seem to be absent. If it can be shown that the red lines 6302 and 6367 are identical with oxygen lines ($^1D_2$-$^3P_{1,2}$) we can no longer doubt that the strong green auroral line originates from oxygen. L. Harang and the writer are trying to measure the two red lines with an interferometer.

If the green auroral line is the OI-line of McLennan, we have to explain why so many oxygen-lines are absent in the auroral spectrum. The writer proposes to explain the predominating intensity of the green line by supposing oxygen to be brought into the OI($^1S_0$)-state through collisions of the second kind with nitrogen in some excited state. The intensity of the green line will then be mainly dependent on the excitation by the electric rays of the predominant atmospheric-component nitrogen. Either nitrogen in the metastable $N^A{}_2$-state may act on ozone, or "active nitrogen" may transfer its energy to a normal oxygen molecule and produce dissociation into one normal oxygen-atom and one in the $^1S_0$-state. The energies engaged nearly balance, so the probability of excitation is increased by a kind of "resonance"-effect. The latter alternative is supported by an important experiment of Kaplan showing that the OI-line 5577 can be excited by "active nitrogen".

REVIEW OF PUBLICATIONS

Planetary Co-ordinates for the years 1800-1940. Prepared by H. M. Nautical Almanac office. London. 156 pp. 9½ × 12 in. Price 12s. 6d. net.

This work has been prepared to fill a long-felt want of the dynamical astronomer in computing definitive orbits or predicting the returns of periodic comets, in fact wherever the computation of perturbations is necessary. For this work the use of a standard fixed equinox is particularly desirable. The rectangular co-ordinates of the planets are given for ten-day intervals referred to the equinox of 1950. This will enable the perturbations to be computed rigorously and with much less labour than formerly, when the computer had these data referred to a constantly shifting equinox.

Besides the tables of the planetary co-ordinates there is a series of tables giving the obliquity and precessional constants, tables for the reduction of star positions, and other tables specially constructed to facilitate the computation of perturbations by the methods of Encke and Cowell.

The first eighteen pages explain the use of the tables and give carefully worked out illustrations, together with many useful hints to the computer in the use of Encke's and Cowell's method of computing perturbations.

The volume is serviceably bound in cloth and clearly printed.

R. K. Y.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Luminous Clouds

Dr. V. H. Macaulay, of Calgary, Alberta, writes regarding a remarkable luminous cloud seen on the evening of September 3. Mr. Andrew Thomson, of the Meteorological Office, Toronto, is of the opinion that this was a mother-of-pearl cloud. I hope to give at a later date further information regarding observations of luminous clouds made in the Canadian west. Dr. Macaulay's description follows:

I have just read the September number of the Journal where reference is made to luminous clouds, and also read the December, 1932, article at the time. I hasten to recount an interesting observation made by myself, my wife and children on the evening of September 3 from 9.10 till 9.30 mountain standard time. The location was in the Bow River Forest Reserve along the Highwood River almost at the foot of the Highwood range of the Rocky Mountains, 70 miles south west of Calgary, Alberta. The moon, one day short of being full, had risen about one-third of the distance to the meridian while slightly above and to the north of it lay an isolated cloud about the shape of a fish with head and tail removed, flat parallel to the earth, and lengthwise from west to east with head to the west, toward the mountains. A typical chinook wind was blowing (from the west of course) at a velocity of about five miles per hour which an hour later freshened to about 30 miles per hour. When first observed one saw three strips through the head of the cloud, alternately a strip of brilliant violet, a strip of brilliant greenish blue and a strip of violet again. The centre band being as wide as the other two together. No other bright colours were visible but there was a fading out at the margins of the strips. The coloured section of the cloud represented about one-sixth of the whole cloud. It did not resemble a rainbow as red, orange and yellow were absent, the colours showing were much brighter than ever seen in a rainbow, no rain had fallen and the bands were not in the form of an arc but ran somewhat irregularly north easterly. There was no halo or ring around the moon, the sky in the neighbourhood being the clear night sky. The cloud itself was white and smooth except on the under side where it was serrated as with waves. The cloud was situated along the margin where hangs the typical chinook arch at which point it appears as though

the chinook meets an opposite wind and slowly turns it back under. Thus the cloud was more or less stationary as the moon slowly moved through the end during which time the colours faded out. The brilliancy of the display was what first attracted my attention. There was no aurora present. There was no pink reflection anywhere from the well known Turner Valley gas flares. The sun had set at about 7.20.

I do not know how unique this phenomenon is, but never having witnessed it before it made such an impression upon me that I decided to write the JOURNAL for an explanation.

A WHITE SPOT ON SATURN

At 12.18 a.m., Saturday, August 5, John E. Willis, of the U.S. Naval Observatory, while observing Saturn with a 6-inch transit circle, observed a white spot on the planet. He had only about a minute before Saturn went out of the field, but he detected the marking and asked others at the Observatory to confirm his observation. This was done with the 26-inch and 12-inch refractors. On the morning of discovery the spot was estimated to be 20,000 miles long and 12,000 miles wide, but the boundary was not well defined. On August 7 the spot was about 19,000 miles long and half as wide, elliptical and symmetrical in shape. The planet had been observed with the same instrument on July 24 and 30, but the spot was not seen. By means of the spot the rotation period of Saturn was deduced to be 10 h. 16.8 m.

The spot was observed with the 40-inch refractor of the Yerkes Observatory on August 11, and was judged to be on the central meridian at 4 h. 44 m. G.C.T. It was estimated to be 1° north of the equator. Using the observation at Washington on August 5, the period of rotation was found to be 10 h. 15 m. The spot was stated to be the brightest of a row of spots strung over 40° in longitude.

At the Lowell Observatory the spot was observed on the central meridian at 4.57 G.C.T., on August 29, and the observation was confirmed photographically.

In 1876 Asaph Hall, with the 26-inch refractor at Washington, observed a white spot, from which the rotation period of 10 h. 14 m. 24 s. was determined. Another spot was observed by E. E. Barnard at the Yerkes Observatory with the 40-inch telescope in 1905.

THE EXPANDING UNIVERSE

In recent years many startling theories and speculations have grown out of researches in the mathematical and physical domain, and none has stirred the imagination more than that of the expanding universe. The evidence in favour of it, both from theory and observation, is very striking and its essential correctness has been widely accepted. I believe it was first proposed by Professor de Sitter, of Leyden, and he has always been one of its ablest exponents. With further investigation and discussion the theory has been somewhat altered and Professor de Sitter's latest views are given in the following paragraphs, as published by *Science Service*:

We have to choose between three types of expanding universe.

The first type begins with zero radius at a finite time in the past, and expands to infinity. The second contracts from an infinite radius to a minimum and expands again to an infinite radius, while the third oscillates in a finite time between zero and a maximum radius.

The third type involves a periodically recurring catastrophe, a theory to which I have a very strong dislike. Until recently I was inclined to believe in the second type.

Lately I have come to think of the first case, where, according to the mathematical idealization, the universe contracted to a point at some definite epoch of time, the galaxies passing simultaneously through this point with the velocity of light. When the galaxies approach very near each other the mathematical approximation breaks down, so that the point becomes finite, and a physical interpretation is possible.

The galaxies can easily penetrate each other. If you put a million galaxies in the space now occupied by one, the stars still have plenty of elbow room. Their mutual distances will still be of the order of 100,000 times their diameters.

The truth of this theory depends on whether the time of passing through the minimum was a very critical epoch or not. It is supported by several indications of a serious crisis three or five billion years ago. The planetary system, according to modern ideas of its origin, is about that age. And a few billion years ago there must have been some very critical event in the history of the galaxies, when they were subjected to very strong perturbations, which were responsible for their rotation, their spiral structure, and the inhomogeneous distribution of matter in them.

THE DOME OF THE FELS PLANETARIUM

There are said to be eighteen Zeiss planetariums in operation now in Europe—one each in Rome, Milan, Stockholm and Moscow; the rest in, I believe, Germany. There is one in Chicago, others are assured for Los Angeles and New York, and that donated by Samuel S. Fels to Philadelphia will be ready in October.

It has heretofore been customary for the inner surface of the dome to be made of stretched cloth on a series of wooden rings so that it really consists of horizontal rings, one above another, each being the frustum of a cone. The sound passes through the cloth and is reflected back and forth by baffle plates until it fades away. The new dome is to be truly spherical in shape, and made of properly bent sheets of stainless steel with each sheet welded to its neighbours. Now a continuous spherical dome is notoriously bad for reverberation, and to avoid this the steel sheets are perforated with holes one-sixteenth of an inch in diameter and one-eighth of an inch apart. It is stated that actual test shows that sound passes readily through such perforated metal. The walls behind the dome are covered with sound-absorbing pads, and in this way the general effect on the lecturer's voice is the same as if he were speaking in the open air.

The planetarium, together with other astronomical equipment, is in charge of Mr. James Stokley, who has recently been united to one who will help him through life. The Editor tenders happy congratulations and best wishes.

C. A. C.

MEETINGS OF THE SOCIETY

AT VICTORIA

During the summer Victoria Centre sponsored a course of three lectures interspersed with observational meetings. A nominal fee of $1.00 for adults and 50 cents for juniors was charged. The lectures were:

1. July 18.—Co-ordinates used in defining the positions of Stars on the Celestial Sphere, by G. Browne-Cave.

2. August 8.—Time and its measurement by sun clock and star, H. Boyd Brydon.

3. August 29.—Optics as applied to the Astronomical Telescope, J. Duff, M.A.

At the observational meetings, the summer constellations were identified and attention given to the relative magnitudes of the lucid stars and their colours. The directions of some of the principal circles were pointed out and distances between stars estimated.

Copies of the summer star map published by the University of Toronto were given to all attending.

Essays were invited on the subjects of the three lectures and prizes for the best essay on each subject were offered. The prizes were kindly presented by members of Victoria Centre. Dr. J. A. Pearce consented to act as judge of the essays received.

It was hoped by this prize essay contest to attract attendance to the lectures to interest non-members in astronomy and to stimulate study of astronomy.

Perhaps the holiday season or the unusual nature of the subjects were responsible, but very few essays were received though copious note taking was observable at all lectures. In this the result was disappointing. Attendance:

Total attending the course	23
Maximum at a lecture	19
Average at all meetings	15
Average at lectures	17
Average at observation meetings	14

Invitations to join the society have been sent to the eleven non-members attending the course.

The committee in charge of the course desires to express its sincere thanks to Mr. W. Burton, who lent his house for the lectures, and to Mr. W. Pope, secretary of the Board of School Trustees, for the use of chairs.

H. Boyd Brydon, *Secretary.*

AT WINNIPEG

February 8, 1933.—The regular meeting was held in Theatre A, University Building, on February 8, 1933.

The speaker for the evening was Mr. A. V. Pigott, and his subject, "Lessons from Orion and the Pleiades".

The great light-houses of the skies were shown and how to find them. Their distances in light years give us some reason for their appearing mere points of light when viewed with the largest telescopes. He spoke of nebulae—other milky ways; island universes—of which some millions are now known—but dealt chiefly with the great nebula of Orion and the nebulosity surrounding and connecting the Pleiades. The study of the spectra of distant celestial bodies as recorded on the photographic plate by the spectrographs of large telescopes, not only tells the nature and composition of the stars, but also their motion in space, which are beyond the range of any telescope.

February 22, 1933.—The monthly Members' Meeting was held in the same place, at 8.15 p.m. President A. W. Megget was in the chair.

The following names of prospective members were proposed:

Mr. F. A. Clark, 5 Raleigh Apts., Ellice and Vaughan Streets, Winnipeg.

T. W. Halligan, 650 Westminster Ave., Winnipeg.

Mr. Harold Taylor, 158 West Gate, Winnipeg.

Mr. Jas. Cameron Coats, 12 Ferndale Rd., Gravesend, Kent, England.

The lecturer for the evening was Professor V. W. Jackson, and his subject The Equation of Time, which was illustrated by charts. A number of questions relating to the subject had been prepared by the speaker and were discussed, which were both interesting and instructive. Sun-dials also were given their place.

March 8, 1933.—The regular monthly meeting of the Winnipeg Centre was held at the University at the usual time, Mr. A. W. Megget, President, being in the chair.

New members elected to membership were: Mr. F. A. Clark, Mr. T. W. Halligan and Mr. H. Taylor, of Winnipeg; and Mr. Jas. Cameron Coats, of Gravesend, Kent, England.

The lecturer was Mr. S. E. McColl, Director of Surveys for Manitoba, and his subject was "Land Surveys, based on Astronomy".

Mr. McColl spoke of the different kinds of surveying with which we are acquainted and especially that of land. He traced the history of land surveying from the earliest times, when boundary stones were used to mark one's property, down to the present, when surveys can be made, based on astronomy, with the greatest precision and efficiency. The moving of any landmark has always been a very serious offence, even punishable by the death penalty, in our own land, not so very long ago. Champlain did some surveying in Canada in 1625.

Great credit is due La Verandrye and his sons for the work of this nature which they did, and to Fidler, whose specially interesting work was in Selkirk and Assiniboia. About fifty years ago Wm. Inkster and Roger Goulet, very efficiently worked in the same parts.

Endless trouble was caused by the "squatting" of former times, and this is no longer permitted. Land is no longer sold by the Dominion until it has been surveyed, which prevents future trouble.

Steel-band tapes are now used for surveying and this method has been so successful that even from South Africa and New Zealand requests have been made for information on this system. They wish to use it there also.

March 22, 1933.—The monthly Members' Meeting was held at 8.15 p.m. at the University. The President, Mr. A. W. Megget, was in the chair.

Since this was the annual spring Members' Night, four speakers, members of the Society, gave addresses. Mr. L. A. G. Lardner's subject, "Does the Earth Rotate?" was the first on the programme. This is a very old question and was not satisfactorily answered until Leon Foucault demonstrated it when he performed his famous pendulum experiment in the Pantheon at Paris in 1851. This experiment is being continually repeated in laboratories and at lectures. A ball is suspended by a fine cord and caused to swing in a definite plane. After a time it is seen that the ball swings in a different direction. The reason is—as was shown in the Pantheon—that the floor revolves, with the rotation of the earth.

Mr. J. H. Kolb spoke on "The Sun", on which we are constantly dependent for heat, light and even life. He spoke of its size, photosphere, sun-spots, eruptions, prominences, and its terrific storms. During total eclipses of the sun, opportunities are afforded astronomers for studying that part of the sun beyond its edge spectroscopically and photographically. It has been found, after much research, that sun-spots are the seats of such violent cyclones, that if one of such struck the earth, it might almost cause another asteroid system.

In the absence of Mrs. A. S. Willis, her paper on Antares, was read by the President, Mr. A. W. Megget. This giant red star 330 light years away, is one of the four Royal or Guardian stars, and we, in this latitude, see it only in summer. Its diameter is about 390 times that of our sun, and its bulk 900 times as large. It is of great assistance in navigation.

Mr. H. Nicholls' subject was "Lunar Shadows". The speaker told of the accuracy with which measurements of the physical features of the moon can be made, its lofty mountains and deep craters, with heavy shadows, and its temperatures from the boiling point to 200° below freezing. Life, as we know it, would be utterly impossible.

April 12, 1933.—The regular monthly meeting was held at the usual time and place. The president was in the chair.

This was the last formal meeting of the season and four addresses were

given by members of the Society. The first speaker was Mr. A. V. Thomas, and his subject, the Conquest of Space, dealt with the progress made in space navigation since Jules Verne sent his imaginary projectile to the moon in 1865. There was a description given of the needs of aircraft, the composition of such, windows, fuel, etc. The rocket is now the proposed plan for navigating space, and speeds of 3000 to 4000 miles an hour are expected. The American Interplanetary Society is working along these lines, and Bishop Barnes, F.R.S., of Birmingham, Eng., and others were quoted as believing that interplanetary communication may one day be established.

Dr. N. J. Maclean then spoke of a recent visit to the Dominion Observatory at Victoria, where Canada's largest telescope—72-inch reflector—is situated, and where the main study is concentrated on the Galaxy. It has now been conjectured that the Galaxy is probably about 65,000 light years away, less than half of the former suppositions. Many plates were shown of different stars of special interest, with nebulous clouds surrounding them. The Great Nebula in Andromeda was particularly interesting.

Mr. D. R. P. Coats gave the next address on The Sun and Radio Reception, particularly with reference to the total eclipse of August 31, 1932. The speaker described the work done by radio engineers at the time of totality of the eclipse, to learn, if possible, the effect of the sun on radio reception. He told of conflicting opinions, as to cause of disturbances to reception, some believing it to be electrons shot out from the sun and others that it was the ultraviolet rays. Many complications during eclipses make definite conclusions as to the sun's effects on radio reception almost impossible.

The fourth and last speaker of the evening was Mr. Norris-Elye and his subject, "Speeds in Space". From the consideration of speeds of motor-cars, air-planes and guns, to that of comets, meteors, stars, lightning and light—speeds of "bodies terrestrial and bodies celestial". It was stated that the deviation of the path of the earth around the sun from a straight line was only one-ninth of an inch in 18½ miles, which is travelled by the earth in one second. The rate of comets is quickened while nearer the sun and lessened when further off, because of the tremendous gravity of the sun. Arcturus, 40 light years away, would require 640 years to be displaced the width of the sun's diameter. Our Galaxy is said to rotate around a centre towards Sagittarius, and one revolution requires 200 million years.

May 3, 1933.—An observation meeting was held on the University grounds under the leadership of Dr. Warren, Mr. Megget and Mr. Morse. Four telescopes were in use. The Society's telescope is available for the use of individual members of the Society, subject to suitable precautions against loss or damage.

Although the evening was not ideal for observation, the moon was very fine and a number of double stars, as Gamma Leonis, Castor, Mizar, Gamma Virginis and Arcturus, also Mars and Jupiter, made very interesting viewing.

J. C. Howey, *Recording Secretary.*

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